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SPACE, ATOMS, MOLECULES AND THE ETHER.

Matter, Ether and Motion. By A. E. Dolbear, Ph.D. English edition edited by Prof. Alfred Lodge. Pp. vii+376. (London: Society for Promoting Christian Knowledge, 1899.)

La Constitution du Monde, Dynamique des Atomes. Par Madame Clemence Royer. Pp. xxii+800. (Paris: Librairie C. Reinwald, 1900.)

Mutmassungen über das Wesen der Gravitation, der Elektricitäts und der Magnetismus. Von Dr. med. Hermann Fischer. Pp. 42. (1899.)

Ueber mögliche Bewegungen möglicher Atome. Von Dr. med. Hermann Fischer. Pp. 92. (Dresden: Hellmuth Henkler, 1900.)

A QUARTER of a century ago the Society for Promoting Christian Knowledge published a small book of 125 pages on "Matter and Motion," by Prof. Clerk Maxwell, and it is interesting to reflect that the necessity of adding the ether to the title of a new book issued by the same publishers is largely due to the important modern developments of the ideas which, in his more abstruse writings, the author of the original book suggested. There is, no doubt, a considerable demand at the present time for a book dealing in a popular way with general notions about molecules and the ether; but it is desirable that, in attempting to meet this demand, scientific accuracy no less than simple and popular treatment should be aimed at.

Dr. Dolbear is fortunate in having it stated conspicuously that his book is "edited by Prof. Lodge," who in his preface remarks that

> "the luminous manner in which the author deals with the great problems as to the nature of electricity, magnetism and the kinetic relations between ether and matter will make this book interesting and instructive to a wide circle of readers."

But even the editor is bound to admit that

> "I do not agree with all the author's statements, particularly that on p. 75, where he maintains that transfers of energy are always from bodies having higher rates of motion to those having lower rates. . . ."

An examination of the book shows that it contains many statements quite as open to objection as that cited by Prof. Alfred Lodge. A few extracts will give an idea of the style of the book.

On pp. 14-17 the author takes a great deal of trouble to prove that we shall never be able to construct a microscope sufficiently powerful to see individual molecules. To prove this, he tries first to argue from a rather farfetched analogy between the powers of the microscope and the stage-coach and the railway; then he refers to the impossibility of seeing molecules owing to their rapid motions; and finally he states that

> "there is every reason to believe that the molecules of all bodies are so perfectly transparent that they could no more be seen than the air, even if there were no difficulty from their smallness and their motions."

It would be more correct to refer to p. 149 and to point out that the limits of microscopic vision are defined by the wave-length of light.

On pp. 48-49, speaking of different kinds of motion, we are told:

> "For instance, a compound of a free path motion with a vibratory motion will give a wave or sinuous motion if the direction of vibration be at right angles to the free path."

A little further down, on p. 49, the author says:

> "Indeed, we know that some sorts of motion are propagated in the ether. For instance, what we call light is an example. Its form is *undulatory;* and as we have seen an undulatory motion is a compound of a rectilinear and a vibratory. . . ."

While seven lines lower down he says:

> "I am not aware that any simple rectilinear motion is known to occur in the ether; there may be, and likely enough is, such."

In speaking of non-Euclidean geometry, he suggests a rather curious idea of the relations between men of science of different countries:

> "This new geometry I have alluded to has been worked at by the best mathematicians of all civilised nations, and they agree in their conclusions. They certainly would not do so if there were the slightest apparent reason for rejecting them; for national jealousies are too strong, and a sense of the value of truth too great, to allow any such notions to gain currency anywhere if there were any possibilities of breaking them down."

Here is how the author defines mass, on p. 61:

> "It has become necessary to find some measure for matter that shall be independent of position, and this has been found by dividing the weight of a body at a given place by the value of gravity at that place and calling the quotient the mass, so that if w represents the weight of the body at a given place and g the value of gravity at the same place, that is the velocity per second that gravity will give to a body if left free to fall, then $w/g = m$, the mass."

This definition is calculated to make any reader think that the mass of a body weighing 1 lb. is 1/32·091 at the equator and 1/32·255 at the poles. How is such an inference to be reconciled with the statement that it is "independent of position"?

Further on (p. 346) we have another definition of mass:

> "Mass as a property of matter is generally defined as the amount of matter considered, and is measured by what is called acceleration, that is, the velocity it acquires in a second when acted on by a constant force or push."

On p. 106 we have the following definition of temperature:

> "The word 'temperature' is used to denote the degree of heat there may be in a unit volume of the substance. . . ."

According to this, calorimetry would be made easy, for (*e.g.*) a cubic foot of lead and a cubic foot of air at the same temperature should contain the same "degree of heat"! As a final sample, we quote the author's explanation of the heating of a gas by compression on p. 322:

> "When a gas is condensed by pressure the individual molecules have less free space to move in, and they consequently collide with each other more frequently. Being

elastic their average amplitude of vibration is increased proportionally, and a greater number of them will strike with greater velocity upon the walls of the containing vessel per second than before. Thus the temperature and the pressure of the gas are increased. We say that mechanical energy has been converted into heat energy, or sometimes simply into heat, though what has really happened has been the transformation of external translational motion into internal vibratory motion, which the elasticity and mobility of the molecules permit. When by friction or percussion a body is heated, the same thing precisely has happened; translatory motion has been transformed into vibratory, through the agency of the molecules, which have, therefore, acted as machines for transformation."

Madame Royer has produced a volume of 800 pages, in which she has endeavoured to expose fallacies in the existing theories of matter and to formulate a new theory of her own. The book is illustrated by coloured plates and pretty pictures of molecules built up of atoms. It deals in turn with the history of theories of matter, properties of atoms, vibratory phenomena (including heat, light, sound, smell and taste), solid bodies, liquids and gases, vital processes, gravity, theory of the tides and cosmic evolution.

Madame Royer seems to believe that atoms are fluids in their nature (the indivisibility of atoms has long been a thing of the past) and that there are three states of the cosmic substances, namely, the initial or ethereal state, in which the atoms are without mass and preserve the properties of perfect fluids; the material state, in which the atoms only possess a variable finite portion of their initial expansive substance and all their fluid properties are attenuated; and the vitaliferous state, in which the atoms are not subjected to the laws of inertia and gravity, but can overcome these in producing automatic movements. No such thing as attraction is supposed to exist, but the fluid atoms are held together by an ethereal pressure; they would be spherical when isolated, but when formed into molecules they become compressed into polyhedral forms. The authoress takes exception to the accepted theory that quantity of matter is synonymous with mass; but does not this mainly depend on what we define to be *matter*?

The explanation of gravity attributes this phenomenon to pulsating pressures in the ether—an idea by no means novel, the hydrodynamical theory of pulsating spheres being well known. How far Madame Royer has worked on old lines, and how far she has invented a new theory, it is not our present purpose to examine. We cannot discover anything very remarkable in her new theory of the tides, the principal point of which appears to be that it is necessary to discuss the tides in the earth and the atmosphere as well as in the sea.

It may be convenient here to state roughly in an abridged form the fundamental assumptions stated on pp. 68-70:

"(1) The primary elements of cosmic matter are volumes of fluid, which tend to expand by reason of their internal activity, but are kept from so doing by external and mutual pressures. (2) The cosmic elements constituted by centres of emission of an indefinitely expansive substance are active, and repel one another according to the law of the inverse square. (3) Ponderable bodies are constituted of elements in which the expansive forces are attenuated, and their inertia is inversely proportional to the radius of their virtual sphere. (4) The masses of ponderable bodies are equal to the sums of the inertiæ of their elements, and vary directly as their number and inversely as the cube roots of their expansive forces. (5) The variations of volume of complex bodies under changes of pressure and temperature are the result of correlative variations in volume of their elements, which remain always in contact and are bounded by planes of mutual intersection. [Is it certain that the boundaries are always plane?] (6) It follows that the universe is absolutely filled [with a medium, of course] under constant average pressure, and the local and temporary variations of pressure are the cause of all motion."

The book is evidently the outcome of many years of thought and study on the part of its writer, and it would be of little use to express a single opinion, favourable or unfavourable, on it in a review. Some of the ideas give one the idea that there is much to be said in their favour. The suggestion that what we call atoms may be represented better by portions of fluid than by solid bodies is, whether tenable or untenable, certainly worth careful consideration, and should, if new, certainly be labelled and consigned to its proper place in the storehouse of accumulated thought which is being built up under the general title of "theories of matter." But is it new?

Dr. Fischer, in his first paper, takes as his starting point Korn's theory, according to which gravitation and electricity are referred to a periodical pressure to which the whole solar system is exposed. He considers, however, that it is not necessary to go outside the solar system to find an explanation of the phenomena, but that they can be explained very well by certain ordered motions within the system itself. He assumes the existence of two kinds of atoms, namely, the atoms of chemical elements and those of the ether. The majority of element-atoms are supposed to be elongated, those of the ether being spherical, of average equal size and practically of the nature of mathematical points.

"Possible motions of possible atoms" is an inviting title for his second paper. Its sections deal with space and time, matter and force, the chemical atoms, the ether atoms, the motion of chemical atoms and molecules, and cosmogony. In summing up, Dr. Fischer arrives at the following conclusions:—(1) Discrete deformable active atoms can only be of approximately spherical shape, never with sharp corners or edges; (2) Element-atoms of the most varied forms can be built up of such discrete atoms; (3) Owing to their activity atoms can move, and every motion is due to some force acting on matter; motion is only produced by leaps or bounds, after which it remains constant in magnitude and direction, and can only increase and decrease by jerks. A curvilinear motion is to be regarded as made up of a series of elementary rectilinear motions; (4) Elastic stresses presuppose deformable active atoms; (5) After elastic repulsions, deformable active atoms of certain dimensions may either designedly come into contact or separate; (6) With regard to oscillatory motions, approximately spherical atoms move uniformly, while element-atoms and molecules, especially those of elongated form, can either be turned about their axes or they can perform elliptic or circular oscillations made up of elements of rectilinear motion in directions along, perpendicular to, or inclined to their axes; or the parts of a molecule may oscillate about their common centre of mass; (7) All oscillations are either ordered or unordered motions.

The various types of oscillation are held by Dr. Fischer to account respectively for chemical light-vibrations, electric light-vibrations, heat, gravity, electric and magnetic phenomena.

While Madame Royer's speculations on the nature of things lead her to think that the laws of nature are never disturbed by "that imaginary being called God, who has no place in an autonomous universe," Dr. Fischer concludes his paper with the quotation

> "Die Himmel erzählen des Ewigen Ehre."

We far prefer the spirit of the latter writer, who in the course of his work clearly sees that theories of matter can but be approximate mechanical representations of the truth. It is true that a good deal of progress has been made of late years in the conception of elements and media which reproduce more or less closely the physical phenomena known to us; but whether we regard the universe as filled with a single medium and atoms as singularities occurring in it, or regard everything, including the ether, as built up of discrete atoms, a reduction of the number of varieties of atoms and media is not necessarily synonymous with an advance in physical theory. What is rather wanted is to reduce to their minimum the number of fundamental hypotheses required for the mathematical deduction of the physical phenomena known to us. This was the spirit which actuated Maxwell, and while since his time we have become more and more familiar with molecules and the ether, it is doubtful whether our advances in reducing their properties to mathematical formulæ have been so great as they ought to be. With the exception of Larmor, there are few physicists now carrying on the work of Maxwell, and there is, unfortunately, a growing school who conceal their ignorance of the causes of things by referring everything to "molecules" or "the ether," and endowing these with new properties without troubling much if such properties are reconcilable with those previously attributed to them. What is equally important, as our theories of matter advance, fresh properties become known to us, so that as soon as we have climbed to the summit of one hill, we see a still higher one ahead. G. H. B.

ALLEGED HYPOSTOMIAL EYES IN THE TRILOBITES.

Researches on the Visual Organs of the Trilobites. By G. Lindström. Kg. Svn. Vet. Akad. Handlg., Stockholm. Bd. 34, No. 8. Pp. 74; 6 plates. (1901.)

THIS memoir of 74 pp., illustrated by six most beautiful plates, deals in reality with the joint labours of the author whose name appears upon the title-page and his talented assistant, G. Liljevall, to whom the first detection of the central fact of the presence of supposed eyes on the labrum (hypostome), the labour of cleaning and preparing the specimens described, and, above all, of making the original drawings (for which no praise can be too high) are due. The material described is mostly a rich collection preserved in the Swedish National Museum; but it is explained, with comment none too flattering, that "collections of foreign species and the waste (vast) European and American literature" have been taken into account. The work opens with a short introduction, dealing mainly with the detailed surface anatomy of the hypostome and the orientation of the supposed hypostomial eyes, or "maculæ," as the authors name them, together with an account of the first observations upon which, by comparison with the cephalic eyes of the compound type, they were led to regard the maculæ of the facetted kind as visual in function. There then follows a chapter upon the blind Trilobites. A detailed dissertation upon the origin and nature of the ridge hitherto designated the "eye-lobe," "ocular fillet," or "Augen Leiste," and known by a variety of other names, next follows; and the authors, finding that "in a long series of genera succeeding each other it has no connection whatever with any eye," prefer to term it the "facial ridge"; and they subdivide the blind species into series characterised by its presence or absence.

In the foregoing section much is made of the young larvæ of Olenellus, discovered by Ford and Walcott, as furnishing a clue to the development of this facial ridge, and of the fact that during the growth process of the higher forms the pygidium follows the head region in order of appearance, and that the intervening "thorax" or body-segments are intercalary in origin. Passing to detail concerning the head, Bernard's terms, "rhachis" and "pleura" are preferably employed, and in dealing with its anatomy a passing compliment is paid to the Japanese embryologist, Kishinouye. Attention is next drawn to an important series of growth stages of Liostracus, described by Brögger in 1875, but generally overlooked, and from the study of these the conclusion is reached that the developmental changes of the head segments in the higher Cambrian and Silurian forms are of a different order to those of the Olenellidæ and Paradoxidæ, which Dr. Lindström would apparently regard as representative members of distinct series; and the final result is arrived at that the earliest oculate genus was Eurycare of the Olenellus schists, and that Olenus and Parabolina were probably blind.

The succeeding section is devoted to the consideration of the eyes of the Trilobites, the detailed structure of which the authors, with immense labour, have investigated, by sections taken at various planes and by other means at their disposal. They have been thus enabled to distinguish four types of cephalic eye, which they believe to have probably succeeded one another in the following order, viz. the simplest or Harpes type, of simple ocelli; the Eurycarid, biconvex or lentiform type; the Megalaspid or prismatic type; and the Phacopsid or "aggregate" type—each of which is duly figured with as much detail as is forthcoming, and in section as observed for thirty-six species. Further detail under this head is impossible in these pages; and we pass at once to the fuller consideration of the "maculæ," or hypostomial eyes so-called.

Although the authors record these organs for some 136 species of thirty-nine genera, they state at the outset that the genera in which they have found them lens-bearing are relatively few, and that the lenses or "granules," even where recognisable, have been found to be present only